

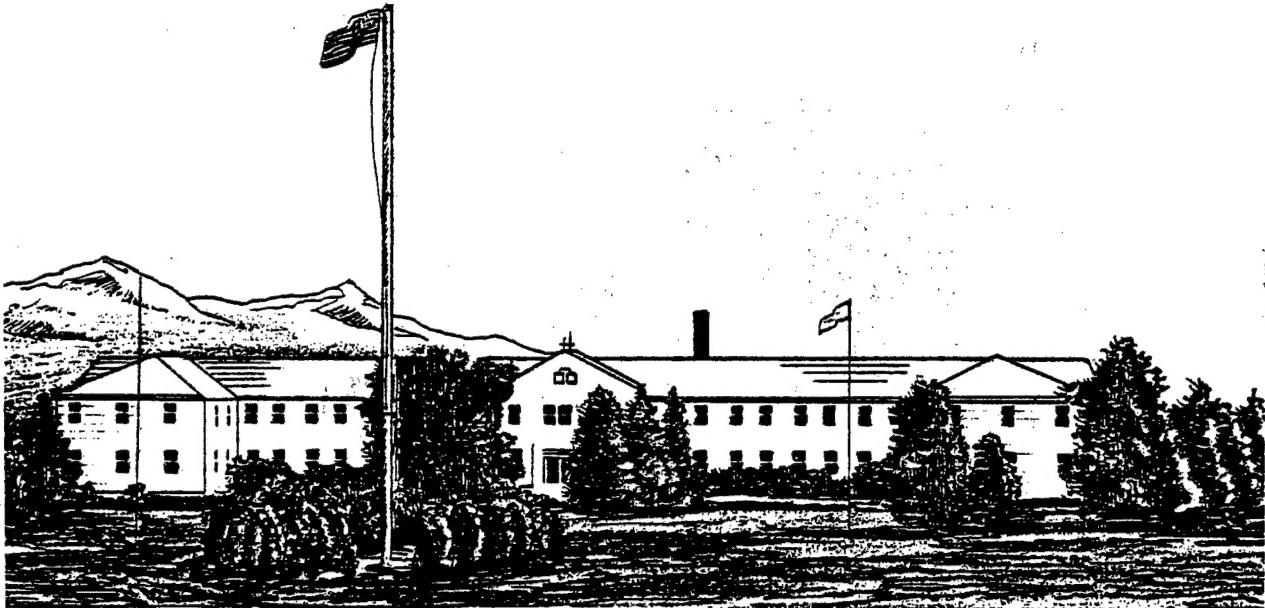
ENERGY ENGINEERING ANALYSIS PROGRAM

FINAL REPORT – INCREMENTS A, B, F AND G

VOLUME 1 – EXECUTIVE SUMMARY

U. S. ARMY

ROCKY MOUNTAIN ARSENAL, COLORADO

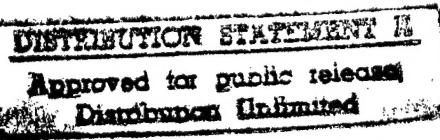


PREPARED FOR:
U. S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT

19971022 110

PROJECT A1-30-30
CONTRACT NO. DACA45-80-C-0091

SEPTEMBER 1983



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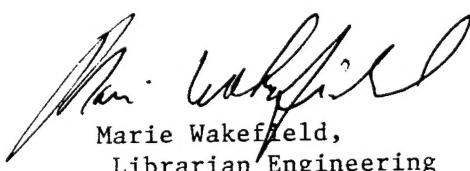


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Marie Wakefield,
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FINAL REPORT

A1-30-30

ENERGY ENGINEERING ANALYSIS PROGRAM

ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

CONTRACT NO. DACA45-80-C-0091

Prepared by
GARD, INC.
Niles, Illinois 60648

For
Department of the Army
Corps of Engineers
Omaha District

September, 1983

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GARD, INC.

PREFACE

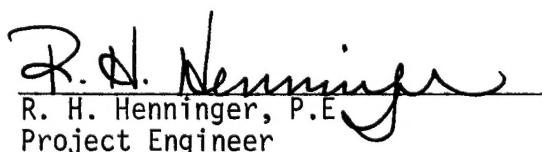
This Final Report summarizes all of the work accomplished under Increments A, B, F and G of the Energy Engineering Analysis Program conducted at Rocky Mountain Arsenal. The tasks assigned under each Increments have been completed and are documented within.

The study objective was to develop a systematic plan of projects that would result in the reduction of energy consumption in compliance with the Army Facilities Energy Plan (AFEP) and to prepare Project Development Brochures (PDB's), DD Forms 1391 and supporting documentation for those projects deemed feasible. The projects developed as a result of this study are described in this report. Project Development Brochures and DD Forms 1391 have been prepared in accordance with Army procedures.

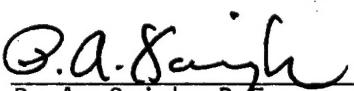
GARD has sincerely appreciated the cooperation that has been extended by members of the Omaha District, Corps of Engineers especially the Program Managers, Mr. S. Owens and Mr. E. Liu, and the Directorate of Installation Services of RMA headed by Mr. David L. Heim.

The GARD project team that conducted this study included C. Schafer, K. Spaulding, M. Hormann, N. Leslie, R. Hedrick and M. Hagen.

Respectfully submitted,


R. H. Henninger, P.E.
Project Engineer

Approved by:


P. A. Saigh, P.E.
Director, Government Programs

ADDENDUM TO FINAL REPORT

The reader's attention is directed to the following which has taken place since submittal of the Advanced Final Report for Increments A, B and G.

1. As of December 7, 1982, the Shell Chemical Company has vacated the premises and no longer provides steam or electric service to the Arsenal. The Central Heating Plant is currently being operated by an outside contractor on a "cost plus" basis. All references to the aforementioned utilities within this report are based on "existing conditions" prior to December 7, 1982. As part of Increment F, various alternatives were evaluated for providing the utility services previously supplied by Shell.
2. In response to Revised ECIP Guidance issued 12/31/82, the Omaha District, Corps of Engineers has reviewed and revised all of the ECIP calculations for each of the ten qualifying projects identified for Rocky Mountain Arsenal. Appropriate changes have been made in pertinent sections of the Project Development Brochures and DD Forms 1391 only. There are several ECOs that do not qualify for project funding in ECIP Projects No. A-1 and A-2 when evaluated under the new ECIP guidelines. Those non-qualifying ECOs deleted from the program documentation are summarized below. The Main Report as well as the Executive Summary have not been revised to include these changes.

Non-Qualifying ECOs Under New ECIP Criteria

Project No. A-1

<u>Building</u>	<u>ECO Description</u>	<u>MBTU</u>	<u>TIC</u>
111	Install Remote Control Thermostatic Valves	369	\$28,635
383	Timeclock Air Handling Unit	7	\$ 397
624	Reduce Window Area	192	\$20,803
631	Increase Roof Insulation	<u>244</u>	<u>\$28,152</u>
	Total	812	\$77,987

Project No. A-2

<u>Building</u>	<u>ECO Description</u>	<u>MBTU</u>	<u>TIC</u>
1710	Reduce Window Area	148	\$18,970
1710	Install Remote Control Thermostatic Valves	<u>220</u>	<u>\$18,085</u>
	Total	368	\$37,055

EXECUTIVE SUMMARY
ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)
INCREMENTS A, B AND G
ROCKY MOUNTAIN ARSENAL, COLORADO

Authorization for Study

This Energy Engineering Analysis Program (EEAP) for Rocky Mountain Arsenal (RMA) was conducted under Contract No. DACA45-80-C-0091 issued by the Omaha District, Corps of Engineers to GARD, INC., Niles, Illinois on 13 August 1980. The scope of work was structured into work increments with Increments A and B authorized under the original contract, Increment G authorized under Modification 1 dated 3 March 1981 and Increments B (expanded EMCS) and F authorized under Modification 2 dated 20 May 1982.

Objectives and Scope

The overall objectives of the EEAP are:

- a) "Develop a systematic plan of projects that will result in the reduction of installation energy consumption in compliance with the Army Facilities Energy Plan (AFEP)."
- b) "Develop Coordinated Basewide Energy Systems Plans."
- c) "Prepare Project Development Brochures (PDBs), DD Forms 1391 and supporting documentation for all feasible energy conservation projects."

The EEAP scope of work is divided into seven (7) increments which include the following:

Increment A - ECIP* Projects for Buildings and Processes

Increment B - ECIP Projects for Utilities, Energy Distribution Systems and Energy Monitoring and Control Systems (EMCS)

Increment C - Renewable Energy Systems Projects

*ECIP - Energy Conservation Investment Program

Increment D - Cogeneration and Solid Waste Plants Projects

Increment E - Central Boiler Plant Projects

Increment F - Director of Installation Services Conservation Measures

Increment G - Projects Identified in Increments A and B that do not
qualify under ECIP criteria

This submittal presents the results of Increments A, B, F, and G through a description of those energy conservation opportunities (ECOs) and ECIP projects that were identified and evaluated as part of these work increments.

Increments C, D and E have not been authorized at this time for Rocky Mountain Arsenal.

Approach

Numerous retrofit modifications referred to as energy conservation opportunities (ECOs) were identified for each building, system and central plant studied. Each ECO was evaluated separately using the life cycle costing methods described in the ECIP guidance included as Annex F of the AFEP. Energy savings were determined for each ECO and life cycle benefits were calculated using current mid FY82 fuel costs, which were escalated over the expected life of the modification. Implementation or construction costs were also determined using current FY82 cost data which were escalated to the midpoint of construction assuming an FY86 project award date. Comparison of ECOs was done on the basis of energy-to-cost (E/C), benefit-to-cost (B/C), and simple amortization period (SAP) ratios in accordance with ECIP criteria. Qualifying ECOs were grouped into ECIP projects under the guidance of the Director of Installation Services. Then, once adjustments were made for any interactive or synergistic ECO effects which were present within an ECIP

project, the PDB and DD Form 1391 were prepared for each ECIP project. Non-qualifying ECOs became candidates for implementation as an Increment F or G project.

Facility Description

Rocky Mountain Arsenal (RMA) is part of the United States Army Armament Material Readiness Command (ARRCOM) whose responsibility is the production and readiness of weapons systems. ARRCOM directs operations at four assigned Arsenals including Rocky Mountain Arsenal. RMA has mission responsibility for the manufacture, assembly and demilitarization of chemical munitions.

Rocky Mountain Arsenal is located in Commerce City, Colorado just outside the city limits of Denver and directly adjacent to the Stapleton International Airport (Figure 1). The Arsenal is composed of 385 buildings spread over 25 square miles of land (Figure 2). The buildings range in size from less than 1,000 square feet for family quarters to more than 100,000 square feet for warehouses and production facilities.

The Arsenal is divided into nine sections designated as Areas. An Area map is depicted in the lower right hand corner of Figures 3, 4 and 5 which represent the three Areas with the highest concentration of buildings at the Arsenal. Area 5 is commonly referred to as the South Plants Area and contains buildings owned and used by the Arsenal in addition to buildings built and leased by the Shell Chemical Company (Figure 3). Area 7 is better known as the Warehouse Area (Figure 4) and is composed mainly of warehouse buildings. Area 4 is referred to as the North Plants Area or the G. B. Plants Area (Figure 5) and contains numerous industrial and special purpose buildings used to support various projects involving the production, storage and demilitarization of toxic chemicals and materials. Most of the buildings in Area 4 are presently inactive and have been shut down for many years.

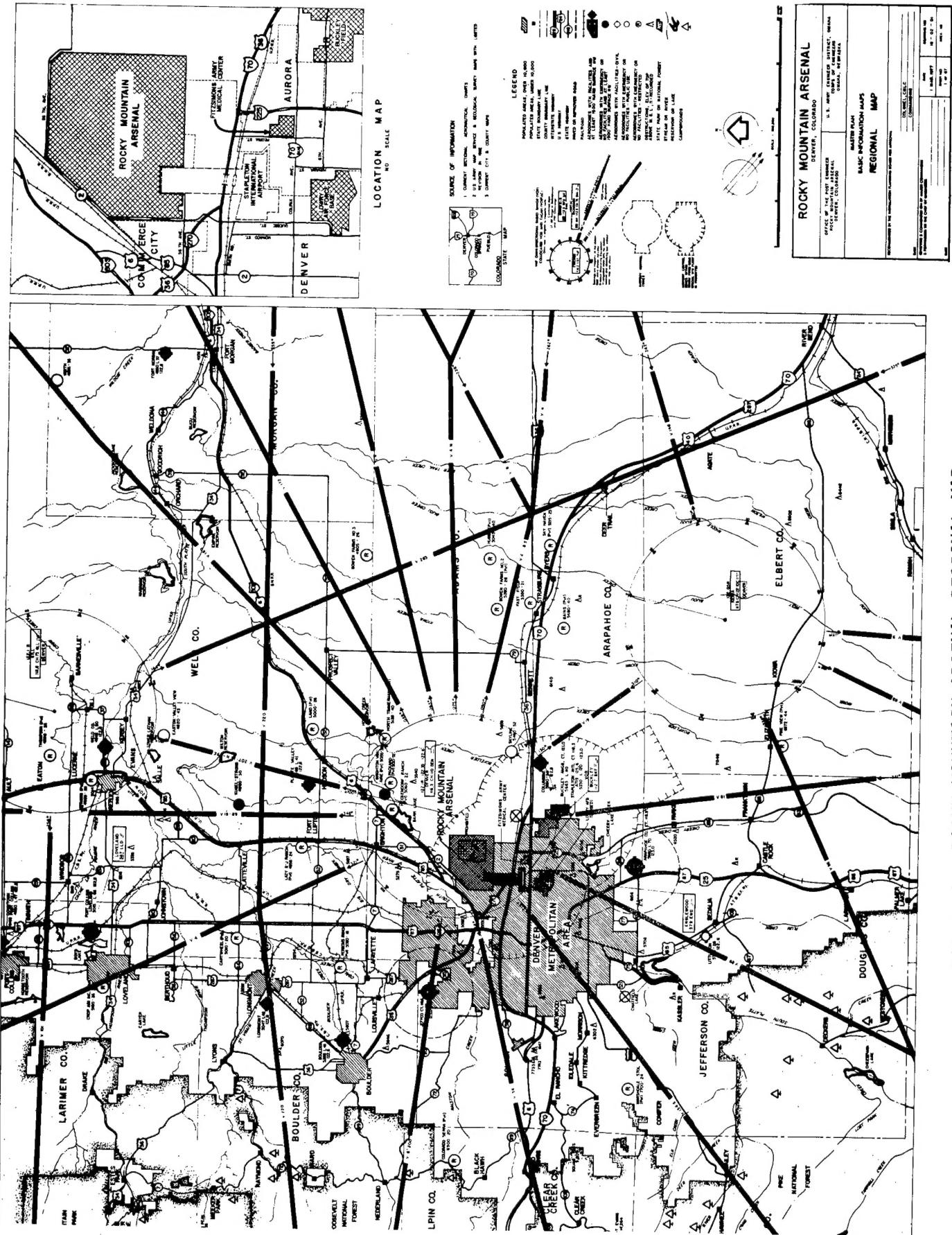


Figure 1 ROCKY MOUNTAIN ARSENAL REGIONAL MAP

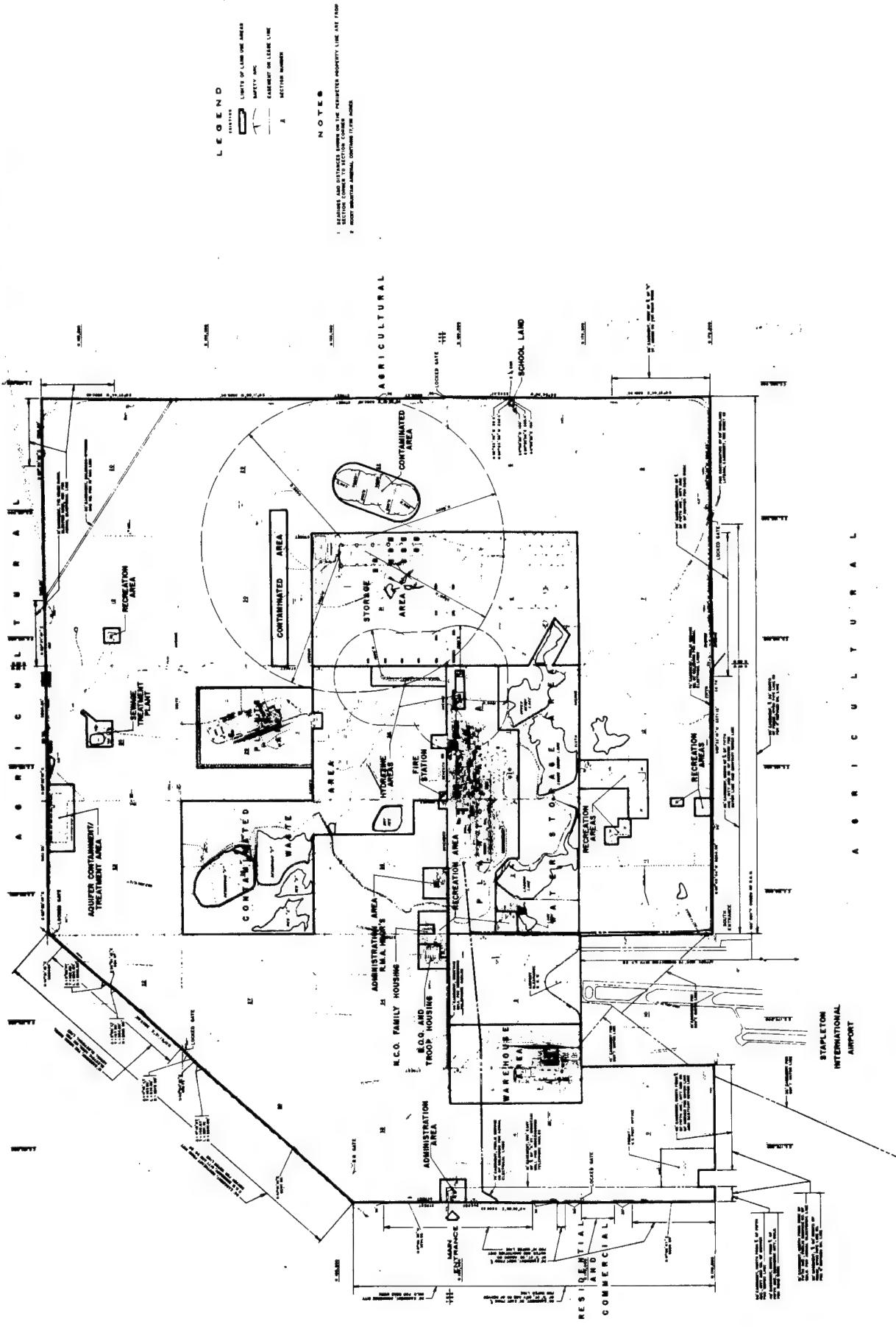


Figure 2 ROCKY MOUNTAIN ARSENAL RESERVATION MAP

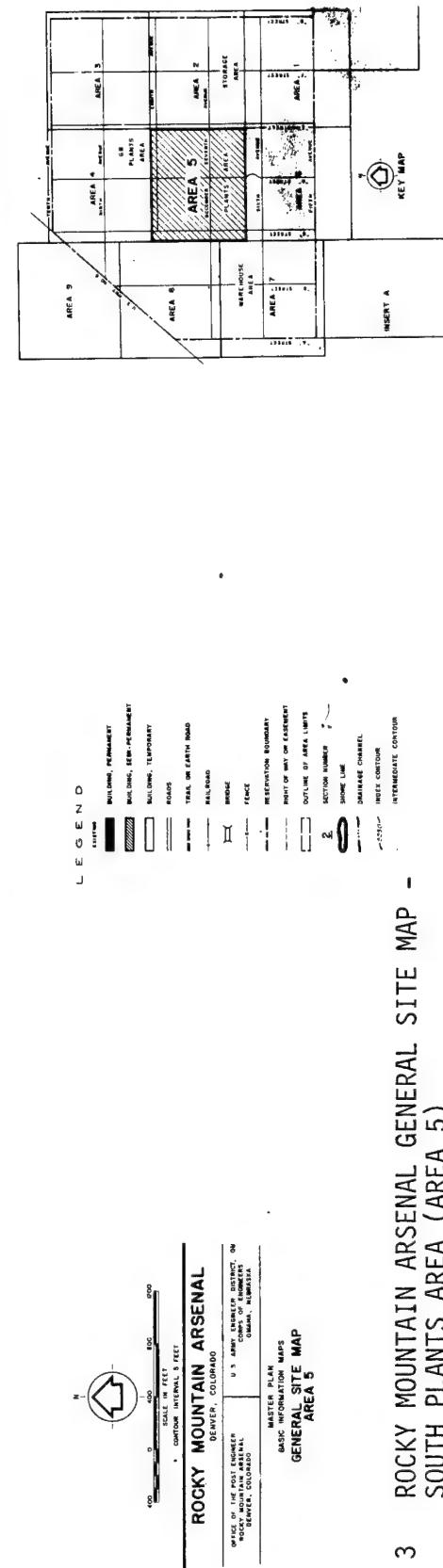
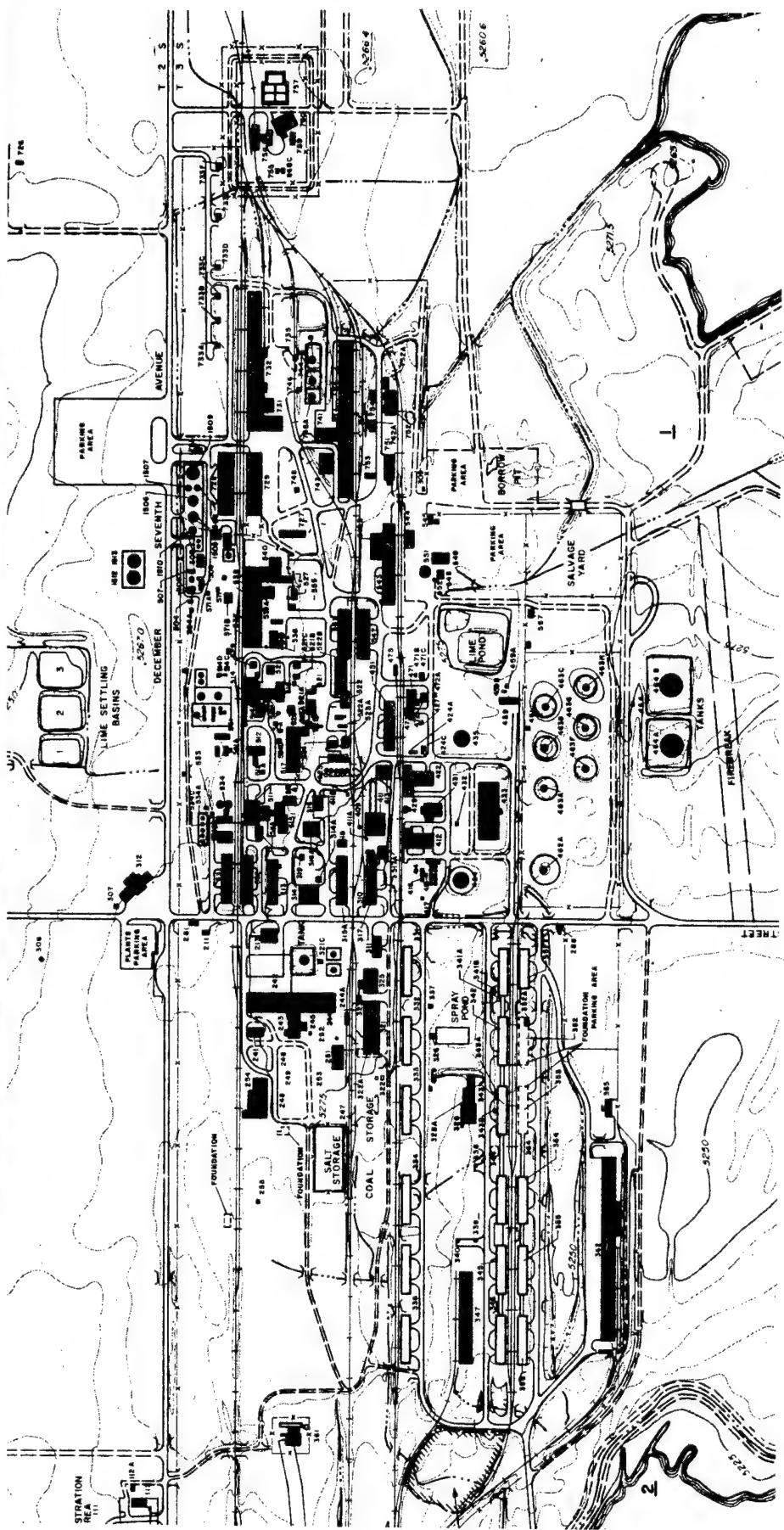


Figure 3 ROCKY MOUNTAIN ARSENAL GENERAL SITE MAP - SOUTH PLANTS AREA (AREA 5)

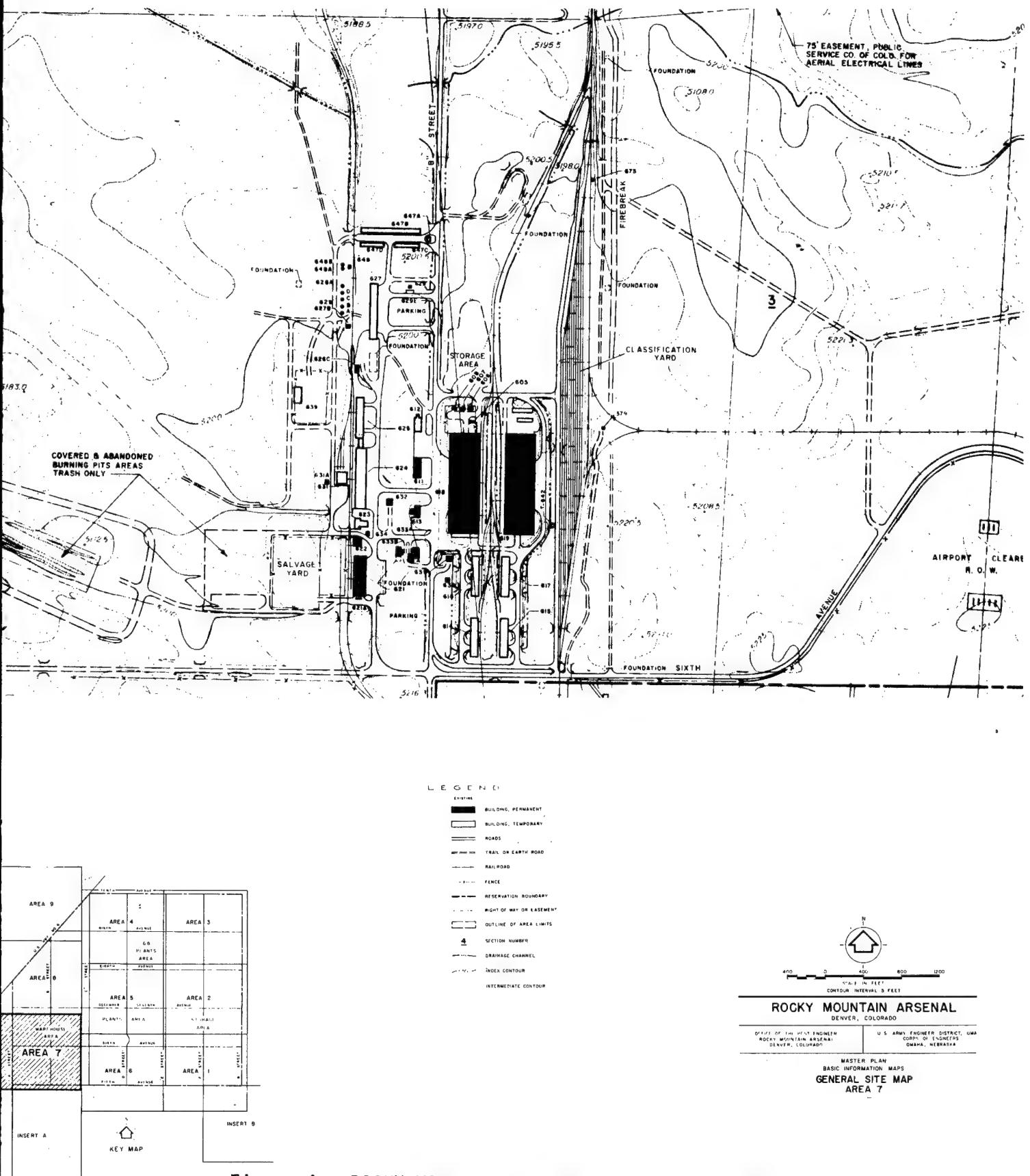
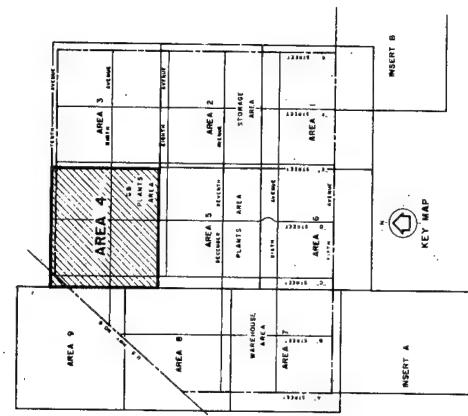
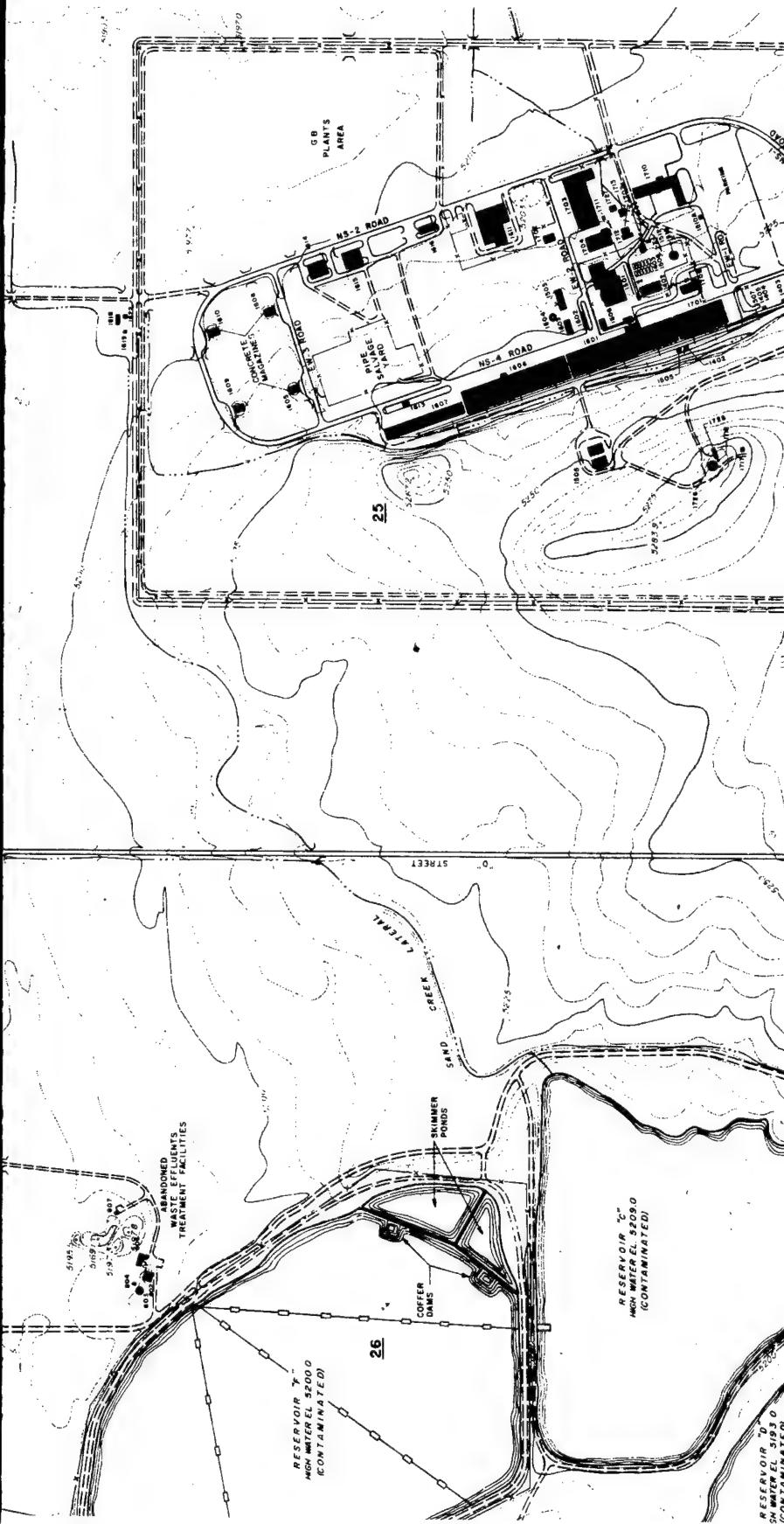


Figure 4 ROCKY MOUNTAIN ARSENAL GENERAL SITE MAP -
WAREHOUSE AREA (AREA 7)

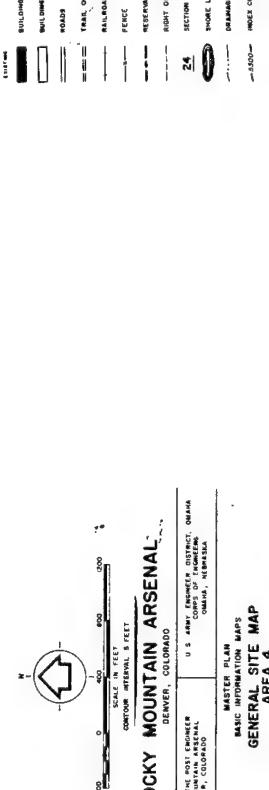


ROCKY MOUNTAIN ARSENAL
GENERAL SITE MAP -
NORTH PLANTS AREA (AREA 4)

OFFICE OF THE CHIEF ENGINEER
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

U.S. ARMY ENGINEER DISTRICT, DENVER
COLORADO, NEVADA

MASTER PLAN
BASIC INFORMATION MAPS
GENERAL SITE MAP
AREA 4



A total of 101 buildings (Table 1) representing some 1,371,213 square feet were identified for study under this contract. Although these buildings do not represent the total number of existing buildings, they do constitute the majority of buildings which are actively occupied.

The current population of RMA is made up of both resident and non-resident personnel totaling about 350 exclusive of those buildings owned and operated by the Shell Chemical Company. The historical population has varied as indicated in Figure 6 and is not expected to vary significantly over the next five years.

Energy Distribution Systems and Central Plants

The Rocky Mountain Arsenal utilizes four major sources of energy to support facilities operations: electricity, natural gas, liquified petroleum gas and No. 2 fuel oil. Electricity is used for lighting, heating, ventilation, process operations, computer equipment and miscellaneous electrical equipment. Natural gas is purchased directly from the Public Service Company of Colorado (P.S.C.) and is used directly by the Arsenal for the purposes of space heating and process operations. Natural gas is also used for the purpose of generating steam at the central heating plant (Buildings 321/325) which is leased, operated and maintained by the Shell Chemical Company. Steam is then purchased by the Arsenal and used primarily for space heating with the remaining bulk of the steam produced being used by Shell to support their Chemical Plant operations. L.P. gas is used at remote building locations for space heating of buildings which cannot readily be served by the natural gas distribution network. No. 2 fuel oil is used only in the North Plants Area to provide space heating and to serve process application requirements. Figure 7 depicts schematically the various uses that each energy source is put to.

TABLE 1
SUMMARY OF ROCKY MOUNTAIN ARSENAL
BUILDINGS DESIGNATED FOR STUDY

Building No.	Title	Function	No. of Floors	Gross Sq.Ft.
111	Administration	Administration	2	47,802
112	Communications	Utility	2	2,275
131	Family Quarters	Housing	1	887
134	Family Quarters	Housing	1	1,120
141	Security Office	Administration	1	5,910
149	Administration	Administration	1	4,048
213	X-Ray Lab	Laboratory	1	4,466
241	Storage	Storage	1	3,200
242	Chlorine Manufacturing	Industrial	1	42,608
243	Chlorine Manuracturing	Industrial	1	16,312
245	Electrical Sub Station	Utility	1	216
251	Storage	Storage	3	22,692
312	Fire Station	Service	2	11,923
313	Laboratory	Laboratory	1	10,155
314	Laundry	Institutional	1	8,640
315	Storage	Storage	1	11,037
321	Boiler Plant	Utility	3	56,479
325	Power Plant	Utility	2	16,500
326	Spray Pond	Special	1	613
328	Manufacturing	Industrial	2	16,534
331	Warehouse	Storage	1	11,037
332	Warehouse	Storage	1	11,037
334	Warehouse	Storage	1	11,037
341	Warehouse	Storage	1	11,037
342	Warehouse	Storage	1	11,037
343	Warehouse	Storage	1	11,037
344	Warehouse	Storage	1	11,037
345	Warehouse	Storage	1	11,037
346	Warehouse	Storage	1	11,037

TABLE 1 (Con't.)
SUMMARY OF ROCKY MOUNTAIN ARSENAL
BUILDINGS DESIGNATED FOR STUDY

Building No.	Title	Function	No. of Floors	Gross Sq.Ft.
351	Storage	Storage	1	8,975
362	Warehouse	Storage	1	54,633
365	Blend and Mix	Industrial	1	3,500
368	Swim Pool	Institutional	1	1,420
373	Officers Quarters	Housing	2	1,393
383	Officers Club	Institutional	1	6,000
391	Sewage Test	Utility	1	72
392	Sewage Lift Station	Utility	-	-
393	Sewage Lift Station	Utility	-	-
411	Manufacturing & Storage	Industrial/Storage	1	14,553
412	Manufacturing	Industrial	2	24,414
413	Chemical Storage	Storage	1	5,432
431	Production	Special	1	6,256
433	Production	Industrial	1	8,910
522B	Change House	Special	1	5,083
523	WP Filling	Industrial	1	4,040
527	Change House	Special	1	1,600
536	Demilitarization	Industrial	1	4,120
537	Transfer and Storage	Industrial	1	15,784
538	Furnace	Industrial	1	8,981
538A	Comp. House	Industrial	1	699
540	Spray Dryer	Special	1	4,907
541	WP Filling	Industrial	1	12,907
542	Warehouse	Storage	1	11,037
543	Maintenance Shop	Service	1	22,495
543B	Maintenance	Service	1	7,727
546	Sewage Lift Station	Utility	-	-
611	Administration	Administration	1	4,478
613	Management Information System Office	Administration	2	6,408
614	Fitzsimmons Warehouse	Storage	1	11,037

TABLE 1 (Con't.)
SUMMARY OF ROCKY MOUNTAIN ARSENAL
BUILDINGS DESIGNATED FOR STUDY

Building No.	Title	Function	No. of Floors	Gross Sq.Ft.
615	NBS Warehouse	Storage	1	11,037
616	Warehouse	Storage	1	11,037
617	G.S. Warehouse	Storage	1	11,037
618	Warehouse & Office	Storage	1	109,402
621	Sales Office & Warehouse	Storage	1	18,212
623	Carpenter Shop	Service	1	4,040
624	Warehouse	Storage	1	23,760
625	Warehouse	Storage	1	11,037
627	Vehicle Service Garage	Institutional	1	15,000
631	Railroad Engine Shop	Service	1	4,644
632	Boiler Plant	Utility	1	1,390
731	Army Reserve	Training	1	12,152
732	Army Reserve	Training	2	62,156
741	Laboratory	Special	2	6,715
742	Vehicle Storage	Storage	1	49,475
743	Laboratory	Special	1	5,400
751	Maintenance Shop	Service	1	5,069
752	Maintenance Shop	Service	1	5,069
755	Change House	Special	1	480
756	Change House	Special	1	648
757	Mixing Facility	Storage	-	-
802	Industrial Waste	Utility	1	2,484
831	Explosive Ordnance Disposal Office	Service	1	1,941
836	Air Force Facility	Training	1	6,912
866	Sewage Disposal Office	Laboratory	1	2,326
1501	Manufacturing	Industrial	6	79,426
1503	Scrubber	Special	1	-
1506	Storage Vault	Storage	1	9,242
1509	Distillation Tower	Special	-	-

TABLE 1 (Con't.)
 SUMMARY OF ROCKY MOUNTAIN ARSENAL
 BUILDINGS DESIGNATED FOR STUDY

Building No.	Title	Function	No. of Floors	Gross Sq.Ft.
1601	Decontamination	Industrial	1	61,813
1601A	Demilitarization	Industrial	1	1,632
1602	Scrubber Building	Special	1	2,378
1603	Scrubber	Special	1	-
1606	Manufacturing	Industrial	1	62,184
1607	Warehouse	Storage	1	27,000
1611	Honest John	Industrial	1	22,227
1701	Warehouse	Storage	1	25,704
1702	Weld Shop	Industrial	1	2,400
1703	Spray Dryer	Special	1	30,906
1704	Utility	Utility	1	8,585
1710	Administration & Dispensary	Administration/ Institutional	1	14,317
1712	Central Heating Plant .	Utility	1	2,365

ROCKY MOUNTAIN ARSENAL
HISTORICAL POPULATION PROFILE

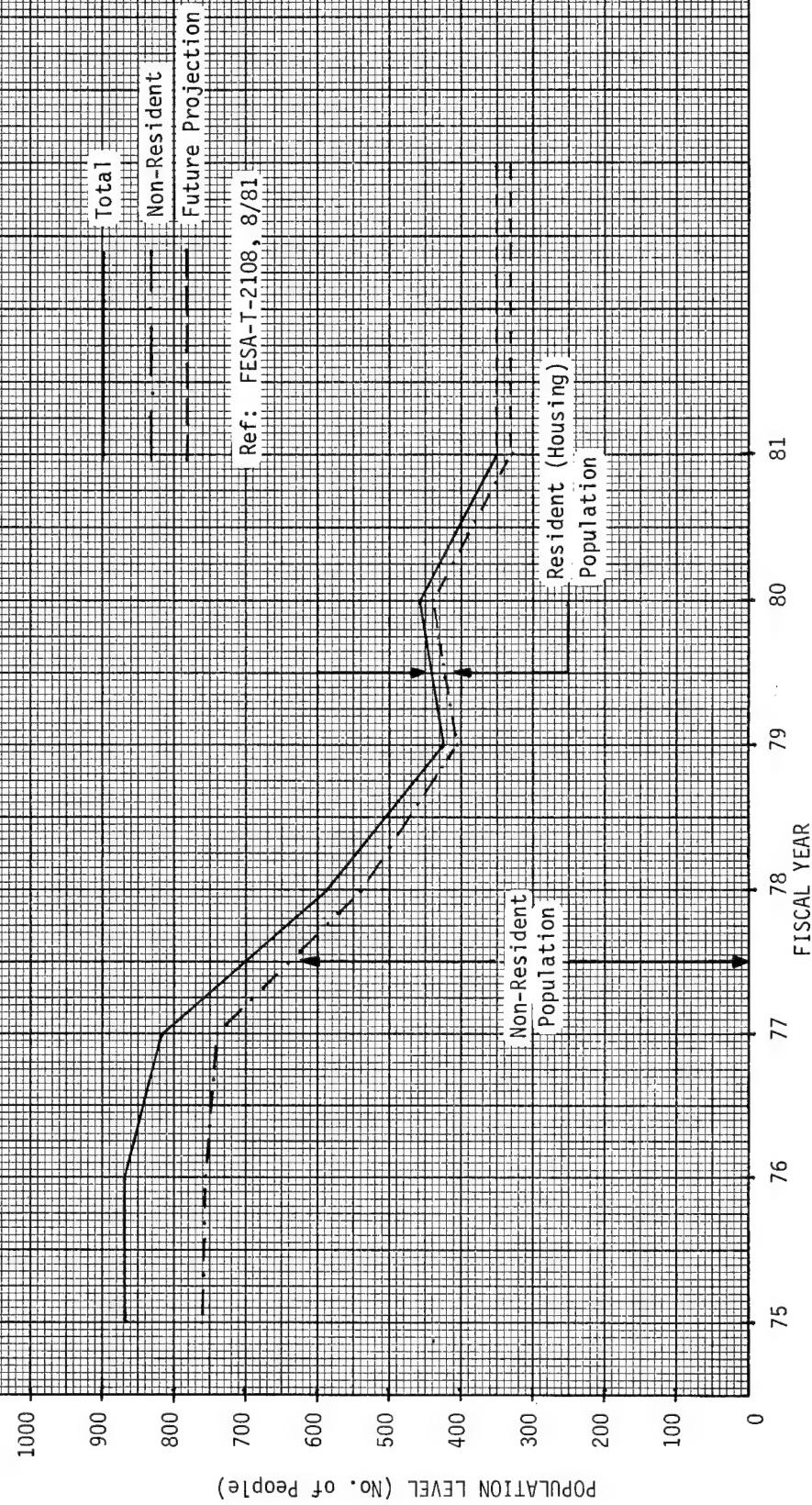


Figure 6 ROCKY MOUNTAIN ARSENAL HISTORICAL POPULATION PROFILE

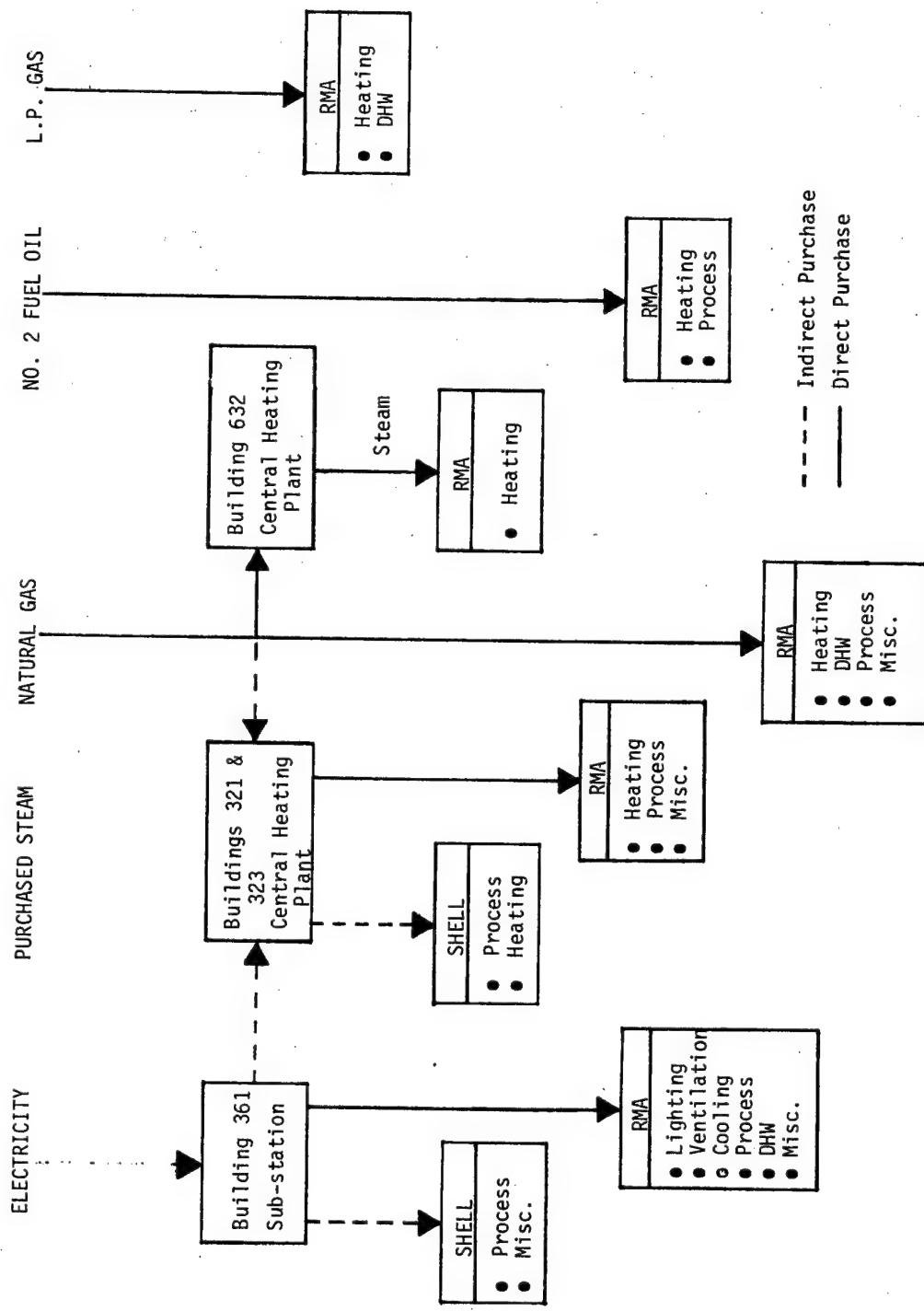


Figure 7 ROCKY MOUNTAIN ARSENAL UTILITIES USAGE DIAGRAM

Various forms of energy, both purchased and/or generated, are distributed throughout the installation from site entry points or central plants to the end users which are typically buildings. The energy distribution systems in use at RMA along with the central plants that supply these systems are summarized in Table 2 and are graphically displayed in Figure 8.

As of December 7, 1982, the Shell Chemical Company has vacated Rocky Mountain Arsenal and no longer provides steam or electric service to the Arsenal. GARD has studied the impact of these changes under Increment F.

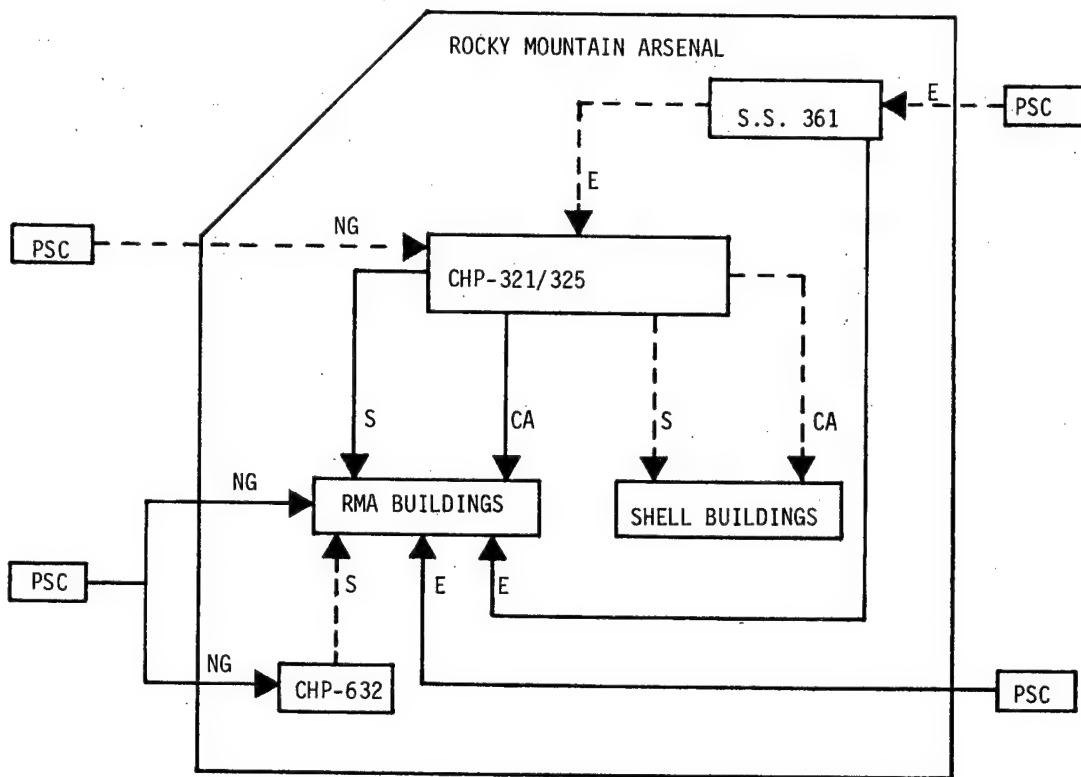
Summary of Site Energy Conservation Actions

Significant progress in reducing energy consumption has been made at Rocky Mountain Arsenal. The large reduction in energy consumption is due primarily to the scaling down of operations and reduced occupancy levels. In addition, numerous projects have been implemented or identified by the Director of Installation Services to conserve energy. Energy conservation projects that have been implemented or programmed (underlined) are listed below.

- All thermostats for heating, air conditioning and hot water systems were reset in accordance with army standards.
- Ceiling Insulation - Buildings 111, 131, 134, 312, 313, 373
- Roof Insulation - Buildings 362, 618
- Storm Windows - Buildings 111, 131, 134, 141, 312, 313, 373, 543B, 741, 866
- Delamp - Building 836
- Night Setback Thermostat - Building 383
- Thermostatic Radiator Valves - Buildings 111, 312

TABLE 2
ROCKY MOUNTAIN ARSENAL
DISTRIBUTION SYSTEMS AND CENTRAL PLANTS

Energy Form	Source	Distribution System	End User
Electricity	Shell Chemical Co. (Bldg. 361) Purchased from the Public Service Company of Colorado & Resold to RMA	6 Primary Feeders @ 13.8 KV	Arsenal Buildings, Tenants & Security Lighting
	The Public Service Company of Colorado	Low Voltage Distribution System (Remote Sub- Metering by PSCC)	South Guard Shack, North Boundary Project & Perimeter Air Monitoring Stations
Steam	Shell Chemical Co., Building 321 & 325 (CHP-321/325) Capacity: 6.3×10^5 LB/HR Fuel: Natural Gas or No. 6 Fuel Oil	Aboveground Insulated Piping @ 200 PSI	22 Arsenal Buildings and 14 Shell Buildings located in Area 5 (Space Heating & Process Loads)
	Building 632 (CHP-632) Capacity: 400 HP Fuel: Natural Gas or Fuel Oil	Aboveground Insulated Pipes @ 15 PSI	6 Buildings Located in Area 7 (Space Heating)
Natural Gas	The Public Service Co. of Colorado	Belowground Piping Network Submetered @ 10 Remote Locations	14 Buildings (Process Loads, Demi. Operations, Space Heating & Service Hot Water Requirements)
Compressed Air	Shell Chemical Co. (Bldg. 321), 3 Fuller Rotary Compressors (Model C300-300H) Rated @ 300 HP Each	Aboveground Pipes @ 100 PSI	Industrial & Laboratory Buildings (Area 5 Buildings)
Condensate	Most Buildings Supplied with Steam From CHP-321/325 or CHP-632	Aboveground Insulated Pipes	Buildings 321 & 325 (CHP-321/325) Building 632 (CHP-632)



ENERGY DISTRIBUTION SYSTEMS

- ELECTRICITY (E)
 - STEAM (S)
 - NATURAL GAS (NG)
 - COMPRESSED AIR (CA)
 - NO. 2 FUEL OIL (STORED)
 - LIQUIDIFIED PETROLEUM GAS (STORED)
- INDIRECT PURCHASE BY RMA
 ——— DIRECT PURCHASE BY RMA

Figure 8 ROCKY MOUNTAIN ARSENAL
ENERGY DISTRIBUTION SYSTEMS

- The main steam lines providing steam to the South Plants Area from CHP-321/325 were reinsulated with two inches of Thermal insulation.
- Inactive and underutilizing buildings throughout the Arsenal have been shut down and operations consolidated where possible.
- Operating procedures have been changed to coincide with reduced activity levels, i.e., the laundry (Building 314) is in use only once a day for several hours in the morning because of the reduced work load.
- An on-site oil fired boiler was installed in Honest John (Building 1611) so that steam would not have to be provided by the CHP-321/325, thereby eliminating excessive steam distribution system losses.

Historical Energy Data

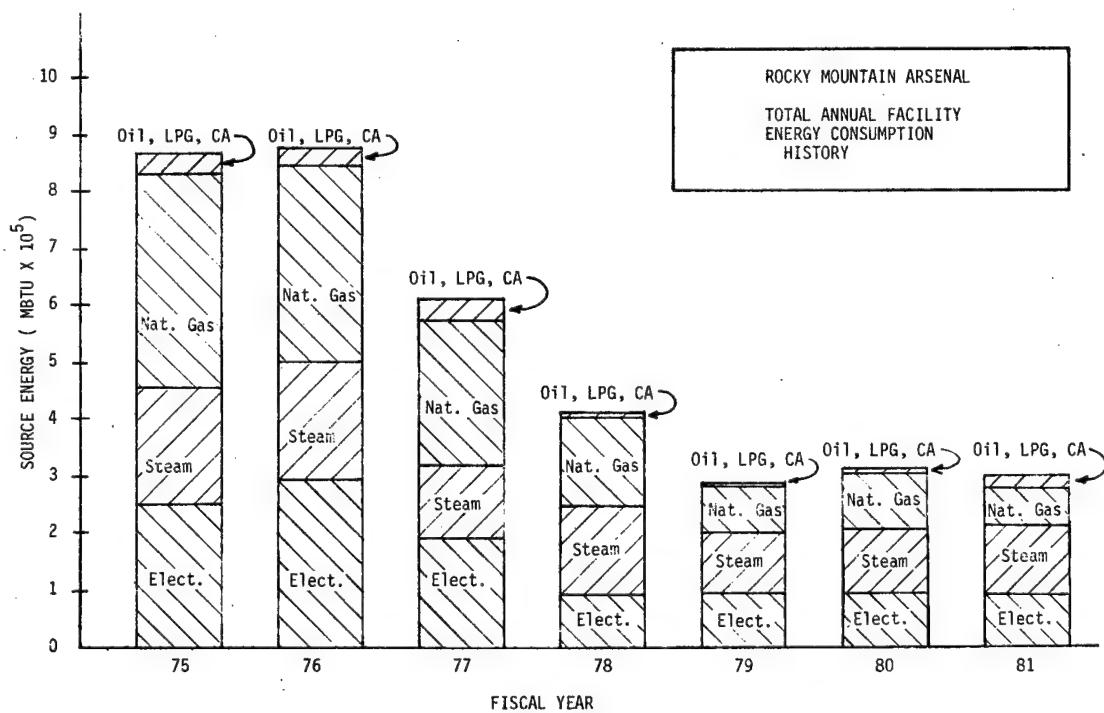
Data for the consumption of purchased utilities at Rocky Mountain Arsenal was obtained from utility records provided by the Shell Chemical Company, the Installation Services Directorate at RMA, the Public Service Company of Colorado and from DARCOM Energy Management Information (DEIS) reports. The annual facility energy consumption history for each utility purchased by RMA during the past ten years is listed in Table 3 and graphically displayed by energy source in composite form for FY75-82 on Figure 9. The annual consumption of all purchased utilities with the exception of L.P. gas are currently well below the levels of FY75.

The total annual facility-related energy consumption at the installation for the years FY75 and FY81 are summarized and compared in Table 4 and Figure 10. Data for FY75 and FY81 were taken from DARCOM Energy Management Information System (DEIS) reports. Each form of energy has been converted to its heat energy equivalent in MBTU's and summed to yield the total annual raw source energy consumed by the Arsenal.

TABLE 3
RMA ANNUAL FACILITY ENERGY CONSUMPTION HISTORY
FISCAL YEAR 1972 to 1981

YEAR	HDD	ELECTRICITY (KWHx10 ⁶)	STEAM (LBMx10 ⁶)	NATURAL GAS (FT ³ x10 ⁶)	COMP. AIR (FT ³ x10 ⁶)	L.P. GAS (GALx10 ³)	#2 FUEL OIL (GALx10 ³)
1972	5685	13.0	117.9	N/A	N/A	N/A	N/A
1973	6515	16.5	113.4	N/A	N/A	N/A	N/A
1974	5806	18.6	114.9	N/A	158.0	N/A	N/A
1975	6297	21.39	145.7	363.4	204.5	24.3	196.9
1976	5587	25.24	147.4	334.5	107.2	76.4	199.5
1977	5403	16.65	91.9	246.2	64.3	23.9	228.3
1978	5795	7.36	113.9	151.2	52.0	21.0	22.2
1979	6422	7.78	80.8	74.7	24.2	29.6	0.4
1980	5965	8.04	83.2	94.3	11.7	45.2	0
1981	-	7.48	92.1	62.0	(19.0)	33.8	143.1

- Notes: 1) Electrical energy shown reflects electricity purchased from the Shell Chemical Co. (Records regarding electricity purchased directly from P.S.C. were limited & accounts for less than 2% of total).
 2) Records for natural gas, no. 2 fuel oil & L.P. gas were not available prior to FY75.
 3) Compressed air date for FY81 is estimated based on available records to date.



**Figure 9 BAR CHART OF RMA ANNUAL
FACILITY ENERGY CONSUMPTION HISTORY**

TABLE 4
 ROCKY MOUNTAIN ARSENAL
 COMPARISON OF TOTAL ANNUAL FACILITY ENERGY CONSUMPTION
 FOR FY75 and FY81

Purchased Utility	Annual Energy Consumption (MBTU)		% Change
	FY75	FY81	
Steam	202,523	128,085	-36.8
Electricity	248,182	86,814	-65.0
Natural Gas	374,689	63,948	-82.9
No. 2 Fuel Oil	27,315	19,853	-27.3
L.P. Gas	2,316	3,234	+39.6
Compressed Air	7,117	661	-90.7
Total	862,142	302,595	-64.9

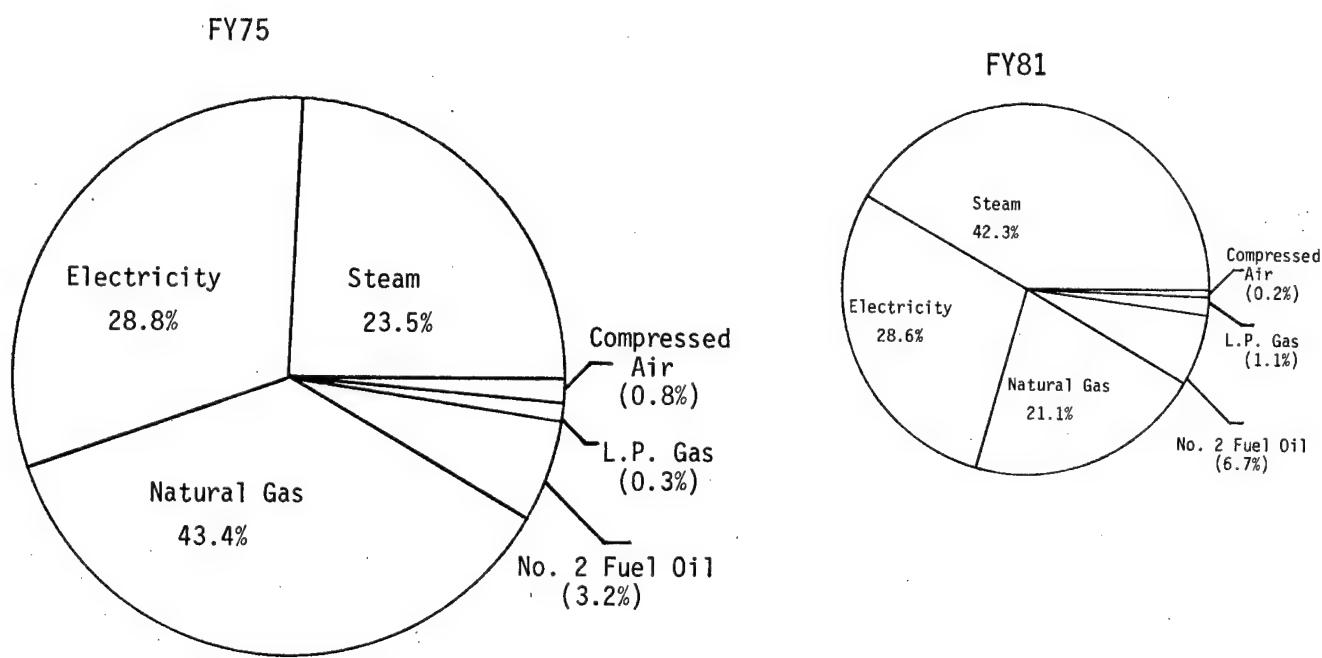


Figure 10 PIE CHART COMPARISON OF RMA TOTAL ANNUAL FACILITY ENERGY CONSUMPTION FOR FY75 and FY81

The annual consumption of raw source energy at Rocky Mountain Arsenal is currently averaging around 302,600 MBTU per year based on FY81 utility records. Current annual energy consumption has been reduced by about 65% compared to FY75 energy consumption levels.

Rocky Mountain Arsenal currently has an annual energy budget of approximately \$1.6 million per year based on FY81 utility records and the proposed utility rate schedules (see Table 5 and Figure 11 for details).

Building Annual Energy Consumption Summary

The calculated annual energy consumption for each active building studied is listed in Table 6. The type and quantity of energy used at each building are shown in their respective units of measure (KWH, CCF, LBM, etc.) and in equivalent energy units to establish a total energy use figure in BTU's. The total calculated energy use for each building was then divided by the gross floor area in square feet to arrive at the Energy Utilization Index (E.U.I.) which has units of BTU's/SQ.FT./YEAR. The E.U.I. is used as a quantitative indicator of how energy intensive a building is and can be used to identify buildings which are potential candidates for energy conservation improvements. The E.U.I. for the central heating plants were calculated based on metered fuel consumption, electrical energy required for the boiler auxiliaries and lighting. The total energy used by the central heating plant in Building 321 and 325 however, is limited to the quantity of steam used by the Arsenal alone.

Summary of Qualifying Projects

A brief description for each of the projects identified and evaluated under the Energy Engineering Analysis Program study is provided in Table 7. The funding requirements and energy cost savings for each of these are summarized in Table 8. The projects presented in this table are listed in order of descending energy-to-cost ratios.

TABLE 5
ROCKY MOUNTAIN ARSENAL ENERGY BUDGET SUMMARY

A) AT PRESENT UTILITY RATES

Purchased Utility	Energy Units	Total Consumption ¹ (Total Units)	Energy Unit Cost (\$/Unit)	Annual Energy Cost		Equivalent Energy Cost (\$/Therm)	
				(\$)	(%)	Site	Source
Natural Gas	CCF	620,250	0.52	319,428	27.6	0.50	0.50
Steam	KLBM	92,147	4.65	428,484	37.0	0.49	0.33
Electricity	MWH	7,484	29.00	217,036	18.8	0.85	0.25
No. 2 Fuel Oil	GAL	143,136	1.17	167,469	14.5	0.45	0.45
L.P. Gas	GAL	33,864	0.62	20,995	1.8	1.17	1.17
Compressed Air	KCF	19,000	0.17	3,230	0.3	1.61	0.47
TOTAL				1,156,642	100.0	0.58	0.38

B) AT PROPOSED UTILITY RATES

Purchased Utility	Energy Units	Total Consumption ¹ (Total Units)	Energy Unit Cost (\$/Unit)	Annual Energy Cost		Equivalent Energy Cost (\$/Therm)	
				(\$)	(%)	Site	Source
Natural Gas	CCF	620,250	0.52	319,428	20.3	0.50	0.50
Steam	KLBM	92,147	7.55	695,710	24.2	0.79	0.54
Electricity	MWH	7,484	48.60	363,722	23.1	1.42	0.42
No. 2 Fuel Oil	GAL	143,136	1.17	167,469	10.6	0.45	0.84
L.P. Gas	GAL	33,864	0.62	20,995	1.3	1.17	0.65
Compressed Air	KCF	19,000	0.36	6,840	0.5	3.47	1.02
TOTAL				1,574,164	100.0	0.79	0.52

Note: 1) Energy Consumption Based on FY81 Utility Records.
 2) Proposed utility rates requested by the Shell Chemical Company for electricity, steam and compressed air, retroactive to September 1981 pending ICC approval.

ENERGY BUDGET SUMMARY

<u>Utility</u>	<u>Annual Cost</u>
Steam	\$ 695,710
Electricity	363,722
Natural Gas	319,428
No. 2 Fuel Oil	167,469
L.P. Gas	20,995
Compressed Air	6,840
	\$1,574,164

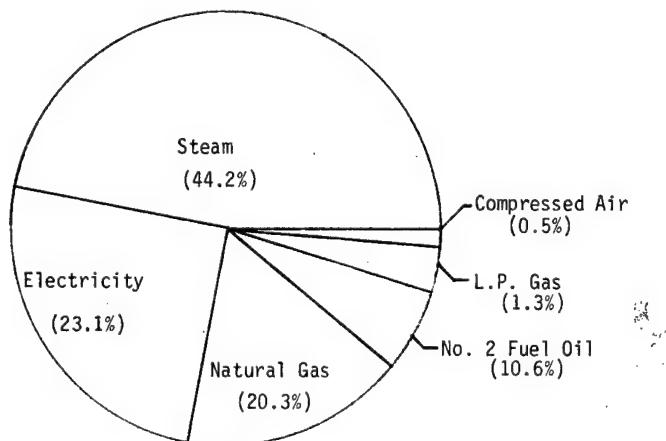


Figure 11 ROCKY MOUNTAIN ARSENAL
PIE CHART OF CURRENT ANNUAL
ENERGY COST BUDGET

TABLE 6
ROCKY MOUNTAIN ARSENAL
BUILDING ANNUAL ENERGY CONSUMPTION SUMMARY

BUILDING DESCRIPTION	FLOOR AREA (SQ FT)	ELECTRICITY (KWH)	STEAM (KLBS)	NAT. GAS (CCF)	FUEL OIL (GAL)	L. P. GAS (GAL)	TOTAL ENERGY USAGE (MBTU)	ENERGY USE INDEX (BTU/SQ FT)
111 - ADMINISTRATION	47802.	227606.		42550.			7027.	147.0
112 - COMMUNICATIONS	2275.	12086.		6152.			774.	340.4
131 - FAMILY QUARTERS	887.	16264.		1486.			342.	385.4
134 - FAMILY QUARTERS	1120.	17897.		1842.			397.	354.9
141 - SECURITY	5910.	57754.		6482.			1338.	226.4
213 - X-RAY LABORATORY	4466.	24913.	727.				1299.	290.9
312 - FIRE STATION	11923.	234600.		9716.			3723.	312.3
313 - LABORATORY	10155.	108713.		1167.	203.		2904.	286.0
314 - LAUNDRY	8640.	57161.		3093.			4962.	574.4*
321 - BOILER PLANT	56479.	175200.					2032.	36.0*
325 - POWER PLANT	16500.	1811718.		1242331.			149100.	9036.0
342 - WAREHOUSE	11037.			2084.			2897.	262.5
343 - WAREHOUSE	11037.			2072.			2881.	261.1
362 - WAREHOUSE	54633.	208644.		11113.			17867.	327.1
368 - SWIMMING POOL	1420.	37700.			20000.		2499.	1760.1
373 - OFFICERS QUARTERS	1393.	10833.		2921.			427.	306.4

* EXCLUSIVE OF ENERGY CONSUMED BY SHELL

TABLE 6 (Con't.)
 ROCKY MOUNTAIN ARSENAL
 BUILDING ANNUAL ENERGY CONSUMPTION SUMMARY

BUILDING DESCRIPTION	FLOOR AREA (SQ FT)	ELECTRICITY (KWH)	STEAM (KLBS)	NAT. GAS (CCF)	FUEL OIL (GAL)	L. P. GAS (GAL)	TOTAL ENERGY USAGE (MBTU)	ENERGY USE INDEX (BTU/SQ FT)
383 - OFFICERS CLUB	6000.	108186.		6088.			1882.	313.7
392 - SEWAGE LIFT STATION	-	54300.					629.	-
393 - SEWAGE LIFT STATION	-	54300.					629.	-
522B- CHANGE HOUSE	5083.	20920.	569.				1033.	203.3
543 - MAINTENANCE SHOP	22495.	132820.	3477.				6374.	283.4
543B - MAINTENANCE SHOP	7727.	31482.	555.				1137.	147.1
544 - MAINTENANCE	3232.	15125.	1103.				1708.	528.6
611 - ADMINISTRATION	4478.	36375.		5133.			951.	212.4
613 - M. I. S. OFFICE	6408.	70871.		1187.			2047.	319.5
618 - WAREHOUSE & SHOP	109402.	73225.		300077.			31787.	290.5
621 - WAREHOUSE & SALES	18212.	59797.		24739.			3244.	178.1
624 - WAREHOUSE	23760.	32007.		49349.			5459.	229.7
627 - VEHICLE SERVICE SHOP	15000.	83142.		34406.			4512.	300.8
631 - R.R. ENGINE SHOP	4644.	41321.		17863.			2321.	499.8
632 - BOILER PLANT	1390.	71100.		160416.			17364.	12491.8
731 - ARMY RESERVE	12152.	56871.	1965.				3392.	279.1
732 - ARMY RESERVE	62156.	182711.	6916.				11732.	188.7

TABLE 6 (Con't.)
 ROCKY MOUNTAIN ARSENAL
 BUILDING ANNUAL ENERGY CONSUMPTION SUMMARY

BUILDING DESCRIPTION	FLOOR AREA (SQ FT)	ELECTRICITY (KWH)	STEAM (KLBS)	NAT. GAS (CCF)	FUEL OIL (GAL)	L. P. GAS (GAL)	TOTAL ENERGY USAGE (MBTU)	ENERGY USE INDEX (kBtu/Sq Ft)
741 - LABORATORY	6715.	33401.	697.				1356.	202.0
742 - VEHICLE STORAGE	16492.	77182.	3686.				6019.	365.0
743 - LABORATORY	5400.	56144.	722.	171.			1672.	309.7
751 - MAINTENANCE SHOP	5069.	14522.	1112.				1714.	338.2
752 - MAINTENANCE SHOP	5069.	12580.	1112.				1692.	333.8
756 - CHANGE HOUSE	648.	2400.	84.				145.	223.8
757 - MIXING FACILITY	-		8077.				11227.	-
802 - INDUSTRIAL WASTE	2484.	278837.					5735.	3782.
808 - NO. BOUNDARY PROJECT	5000.	264168.					4449.	697.9
831 - EXPLOSIVE ORD. DISP.	1941.	11506.					4830.	325.3
836 - AIRFORCE	6912.	63079.					468.	631.
866 - SEWAGE DISP. OFFICE	2326.	12900.					4287.	796.
1602 - SCRUBBER BUILDING	2378.	12600.					5488.	115.2
1611 - HONEST JOHN	22227.	842240.					72649.	240.3
1703 - SPRAY DRYER								325.3
1704 - UTILITY								381.6
1710 - ADMIN. / DISPENSARY	14317.	102347.					3523.	892.9
								446.5
								1148.9
								246.1

TABLE 7
ROCKY MOUNTAIN ARSENAL
DESCRIPTION OF EEAP GENERATED PROJECTS

No.	Project Title	Description
A-1	Various ECOs for the S. Plants Area, Logistics and Administration Buildings	<p>Various ECOs identified under Increment A:</p> <ul style="list-style-type: none"> ● Insulate Walls ● Insulate Roof ● Insulate Ceiling ● Reduce Window Area ● Install Storm Windows ● Weatherstrip and Caulk ● Reduce Infil./Exfil. ● Install Door Seals ● Install High Eff. Lighting ● Timeclock AHUs ● Timeclock Exhaust Fans ● Unoccupied Heating Shutdown ● Night Setback Thermostat ● Install Thermostatic Radiator Valves ● Install Spark Ignition ● Insulate DHW Tanks
A-2	Various ECOs for the N. Plants Area and 800 Series Buildings	<p>Various ECOs identified under Increment A:</p> <ul style="list-style-type: none"> ● Insulate Walls ● Insulate Roof ● Insulate Ceiling ● Reduce Window Area ● Install Storm Doors ● Install Door Seals ● Install High Eff. Lighting ● Timeclock AHUs ● Unoccupied Heating Shutdown ● Night Setback Thermostat ● Install Thermostatic Radiator Valves ● Insulate DHW Tanks
A-3	Heat Recovery for Building 1611	<p>Increment A ECOs which include:</p> <ul style="list-style-type: none"> ● Air to Air Heat Recovery ● Exterior Pipe Insulation ● Bypass S.P.R. Station

TABLE 7 (Con't.)
 ROCKY MOUNTAIN ARSENAL
 DESCRIPTION OF EEAP GENERATED PROJECTS

No.	Project Title	Description
B-1	Steam Distribution System Modifications	An Increment B project consisting of various modifications and improvements to the steam distribution system serving the South Plants Area and including the following: <ul style="list-style-type: none"> ● Insulate Steam Supply & Return Piping ● Install Steam Shut-off Valves ● Modify Steam Piping to Building 522B ● Check and Repair/Replace External Steam Traps
B-2	Small EMCS	An Increment B project consisting of a Small EMCS to provide automatic control and monitoring of HVAC systems in 24 buildings.
F-1	Replace Central Heating Plant and Modify Steam Distribution System	An Increment F project consisting of the following: <ul style="list-style-type: none"> ● Install (2) 400HP Boilers & Aux. ● Construct Prefab. Building ● Remove Existing Pipe Insulation ● Insulate Steam Distribution System ● Install Steam Shut-off Valves ● Repair/Replace Steam Traps ● Piping Modifications to 522B
G-1	Family Housing	Various ECOs identified under Increment A for family housing: <ul style="list-style-type: none"> ● Weatherstrip and Caulk ● Night Setback Thermostat ● Install Spark Ignition ● Insulate DHW Tanks ● Replace Central Heating System

TABLE 7 (Con't.)
 ROCKY MOUNTAIN ARSENAL
 DESCRIPTION OF EEAP GENERATED PROJECTS

No.	Project Title	Description
G-2	Special Projects for Buildings 213, 312, 362, 368 and 621	<p>Various ECOs identified under Increment A which do not meet minimum ECIP funding requirements:</p> <ul style="list-style-type: none"> ● Replace Steam Traps (Bldg. 213) ● Insulate Steam Piping (Bldg. 312) ● Replace H.W. Generator (Bldg. 362) ● Timeclock Pool Heater (Bldg. 368) ● Install Pool Cover (Bldg. 368) ● Insulate Pool Heater (Bldg. 368) ● Insulate Steam Piping (Bldg. 621)
G-3	Submetering of Utilities	<p>Those ECOs identified under Increment B, but do not qualify as ECIP projects.</p> <ul style="list-style-type: none"> ● Install 15 Natural Gas Meters ● Install 35 Electrical Gas Meters ● Install 18 Steam Condensate Meters (S. Plants Area) ● Install 7 Steam Condensate Meters (Warehouse Area)
G-4	In-House Projects	<p>Various low cost ECOs identified under Increment A for buildings throughout the site.</p> <ul style="list-style-type: none"> ● Install Shower Flow Restrictors ● Reset Hot Water Temperature ● Insulate Hot Water Tank ● Reduce Ventilation Air ● Delamp Light Fixtures ● Optimize Temp. Control ● Install Steam Shut-off Valves

TABLE 8

**ENERGY ENGINEERING ANALYSIS PROGRAM
ROCKY MOUNTAIN ARSENAL, COLORADO**

**PRIORITIZED LIST OF ALL QUALIFYING PROJECTS
BY DESCENDING E/C RATIO**

NO.	PROJECT TITLE	ANNUAL ENERGY SAVINGS				DOLLAR SAVINGS (\$1000'S) ANNUAL TOTAL (FY86)	COST (\$1000'S FY86) CWE TOTAL (FY86)	ECIP RATIOS		
		ELECT. (KWH)	NAT. GAS (KCF)	STEAM (KLBS)	ÖIL/LPG (GAL)			E/C	B/C	SAP
G-2	SPECIAL PROJECTS	13388.	2194.	871.0	0.	3627.	33.4	437.0	14.1	14.8
B-1	STEAM DISTRIBUTION	0.	0.	40962.0	0.	56938.	541.4	11039.3	420.5	441.1
G-3	SUB-METERING	374138.	3101.	4607.0	0.	13941.	121.7	1578.4	111.4	116.9
F-1	REPLACE CHP	396240.	95304.	0.0	0.	103886.	930.0	4439.1	849.9	891.6
G-4	INHOUSE PROJECTS	22288.	603.	260.0	0.	1242.	10.9	141.9	11.4	11.9
A-2	N. PLANTS & 800'S	60213.	1472.	0.0	38060.	8106.	105.4	1506.6	89.3	93.7
A-1	S. PLANTS AREA	512587.	32130.	23448.0	0.	71400.	645.2	9510.5	1084.2	1137.5
G-1	FAMILY HOUSING	1442.	253.	0.0	0.	278.	2.4	31.6	5.9	6.2
B-2	SMALL EMC'S	1115782.	19052.	8912.7	20874.	36270.	288.1	4181.3	1111.7	1166.2
A-3	HEAT RECOVERY-1611	-4552.	0.	0.0	20609.	2805.	37.8	523.6	124.5	130.6
PROJECT TOTAL		1375744.	136057.	29186.0	58669.	205550.	1886.7	18168.6	2290.7	2403.2
					6392.					

Notes:

- 1) Project totals do not include the affects of Projects No. B-1 (Steam Distribution System) and B-2 (EMCS).
- 2) Project No. B-1 has been superseded by Project No. F-1 and is identical to B-1 except for the additional replacement of the Central Heating Plant. The energy savings as well as the dollar savings differ due to the change in "existing conditions" before and after December 7, 1982.
- 3) As of December 7, 1982, the Shell Chemical Company has vacated the premises and no longer provides steam or electric service to the Arsenal. The Central Heating Plant is currently being operated by an outside contractor on a "cost plus" basis.
- 4) Steam energy savings are shown for Projects No. A-1, B-1, B-2, G-2, G-3 and G-4 because all of the ECO calculations were based on "existing conditions" prior to December 7, 1982.
- 5) The installation of "local controls" as specified in Projects A-1, A-2, G-2 and G-4 are recommended in lieu of an EMC'S (Project No. B-2).

Implementation of all qualifying projects will require about two million dollars in funding and will yield an equivalent energy savings of 205,550 MBTU/YR of electricity, natural gas, steam, No. 2 fuel oil and L.P. gas.

Energy Goals and Projected Site Energy

According to the most recent DEIS reports, the annual consumption of raw source energy at Rocky Mountain Arsenal is currently averaging around 302,595 MBTU per year for FY81 compared to 862,142 MBTU per year for FY75. Although RMA has already met their goal for a 25% reduction in energy consumption by FY85 compared to FY75 and a 50% reduction by FY2000 as established by the Army Facilities Energy Plan, there is significant potential for further reductions in energy consumption. The large reduction in energy consumption is due primarily to the scaling down of operations and reduced occupancy levels.

Implementation of the projects summarized in Table 7 would reduce RMA's current annual energy consumption by 52% down to 143,995 MBTU per year, which is well below the energy goal for FY2000. The projected annual energy savings assuming all recommended qualifying projects are implemented are graphically displayed on Figure 12 by primary energy source.

Figure 13 depicts total facility annual energy consumption at RMA for the period FY75 to FY81 based on DEIS reports. Future energy consumption was then projected by adding the anticipated effects of implementation of recommended qualifying projects to the FY81 level of consumption.

Assessment and Recommendations

Of the ten projects evaluated and found to be qualified for ECIP funding, the following recommendations are offered:

- Top priority should be assigned to the implementation of Project No. F-1 involving the replacement of the Central Heating Plant (CHP)

and modifications to the steam distribution system. Project No. F-1 supercedes Project No. B-1 and is identical in scope except for the additional replacement of the CHP. The energy savings as well as the dollar savings differ due to the change in "existing conditions" before and after December 1982.

- It is suggested that the use of "local controls" as specified in Projects A-1, A-2, G-2 and G-4 be used in lieu of an EMCS. Project No. B-2 (Small EMCS), therefore, is not recommended for implementation. Approximately 93% of the projected annual energy savings can be accomplished with the use of "local controls", i.e., timeclock, individual controls, etc. for less than 9% of the cost of an EMCS. The cost of using "local controls" is approximately \$100,000 compared to \$1,200,000 for an EMCS, thus requiring over one million dollars to obtain a 7% increase in energy savings. The incremental cost of an EMCS compared to using "local controls" does not meet ECIP criteria for project funding, i.e., $E/C < 13$ and $B/C < 1$.
- Project No. G-3 involves the submetering of utilities, i.e., electricity, natural gas and steam in various buildings throughout the Arsenal. Although the application of additional sub-metering by itself does not reduce energy consumption, it is essential for any energy management program to be effective by identifying sources of energy waste and enhancing the energy savings of other recommended ECOs and projects.
- The remaining recommended qualifying projects should be implemented in order of their economic attractiveness, i.e., SIR, E/C, B/C, etc.

- The heat recovery system (Project No. A-3) recommended for Building 1611 is based on regular scheduled use of the building, i.e., 8 hours per day, 5 days per week, 52 weeks per year. Any reduction in the programmed use of the building will result in a corresponding reduction in energy savings, thereby making it less economically attractive.

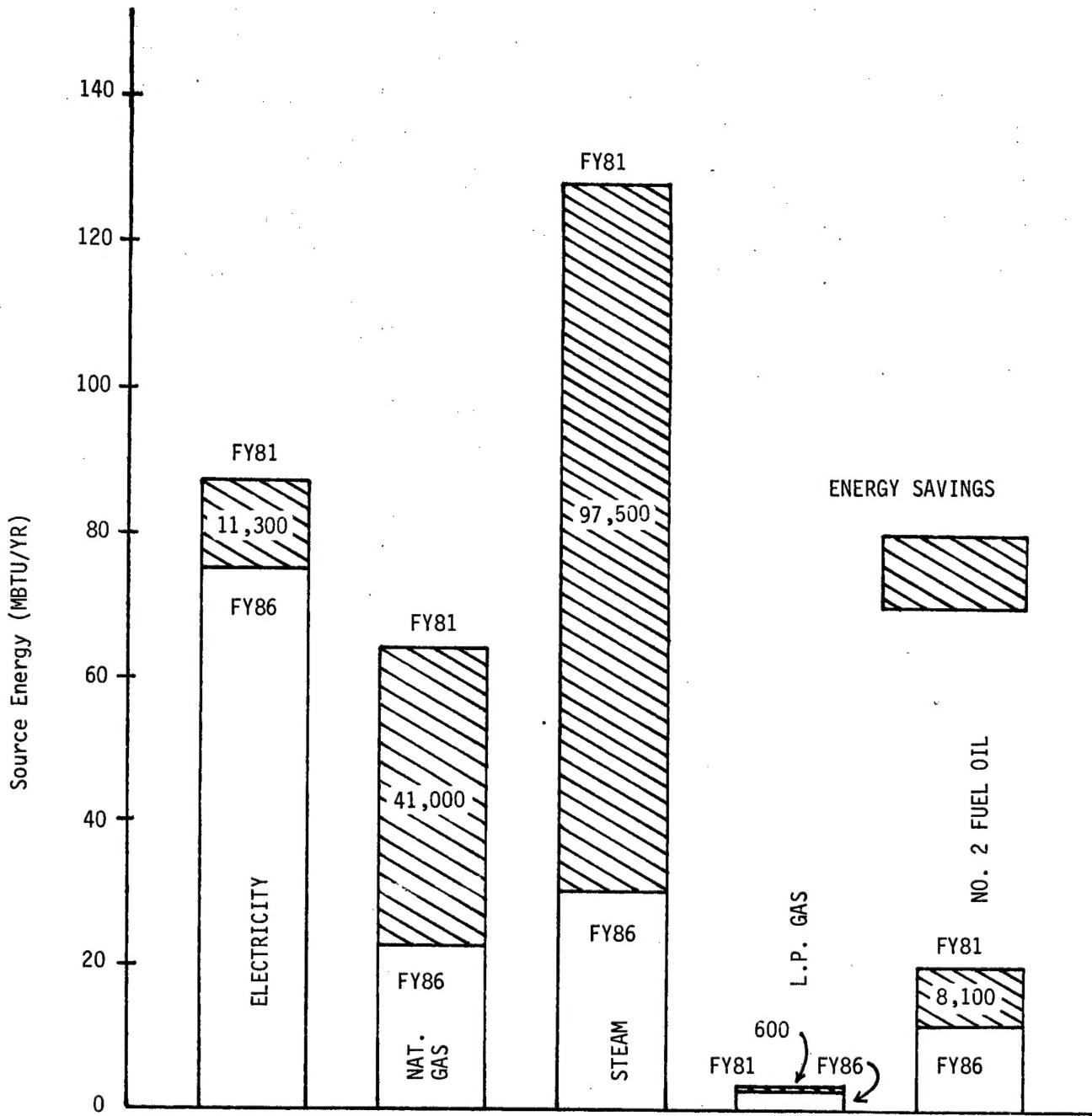


Figure 12 ROCKY MOUNTAIN ARSENAL
PROJECTED ANNUAL ENERGY SAVINGS FOR ALL PROJECTS

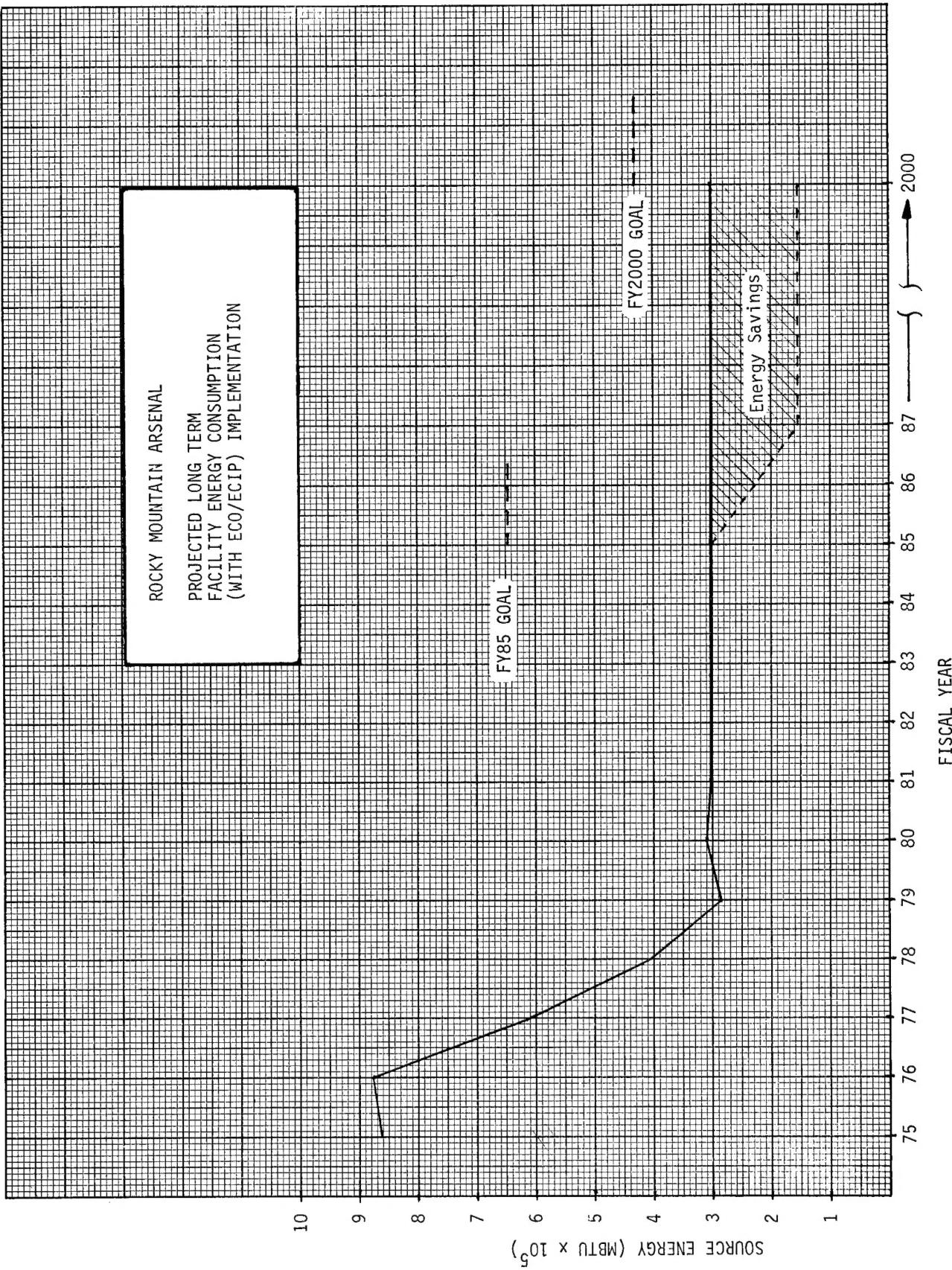


Figure 13 ROCKY MOUNTAIN ARSENAL PROJECTED LONG TERM ENERGY CONSUMPTION (WITH ECO/ECIP) IMPLEMENTATION